

B. Georges Bank Haddock by Jon Brodziak, Michele Thompson and Russell Brown

1.0 Background

The Georges Bank haddock stock was last assessed at the Transboundary Resources Assessment Committee Meeting in 2001. Based on the 2001 assessment, spawning biomass was increasing (59,700 mt in 2000) from a near-record low of 11,400 mt in 1993 and fishing mortality was relatively low ($F=0.19$ in 2000). In this report, we update the Georges Bank haddock assessment using fishery data for 2001 and available survey data for 2001-2002. Updated estimates of spawning biomass and fishing mortality are used for stock status determination. Sensitivity of assessment results to survey trawl warp marking discrepancies during 2000-2002 is evaluated. An updated estimate of the fishing mortality required to rebuild the spawning biomass to B_{MSY} by 2009 ($F_{REBUILD}$) is provided.

2.0 Assessment for 2002

2.1 2001 Landings

US haddock landings were prorated into Georges Bank and Gulf of Maine stock components using a standard algorithm. US Georges Bank haddock landings totaled 4,637 mt in 2001, a 38% increase over 2000 (Table B1, Figure B1). Canadian landings totaled 6,712 mt in 2001, a 24% increase over 2000. US sea sampling data indicated discard rates of 0-5% in 2001 for primary fishing gears. There were no changes in regulatory measures which might have increased discarding. As a result, discards were assumed to be negligible as in the 2000 and 2001 assessments (Brown and Munroe 2000).

US Commercial fishery sampling increased in 2001 (Table B2) for total number of samples (+41%), fish lengths (+43%), and fish ages (+58%) over 2000 sampling. Commercial fishery sampling on western Georges Bank was adequate to compute US catch-at-age on a quarterly basis (Table B2). Sampling was not adequate on eastern Georges Bank to characterize fishery length compositions due to a lack of large and scrod haddock sampling in the second half of the year (Table B2). US Landings are relatively low on eastern Georges Bank (608 mt in 2001) versus western Georges Bank (4,028 mt in 2001). Fisheries in both areas use otter trawl gear and length selectivity is similar. As a result, US catch-at-age data for eastern Georges Bank was computed on a quarterly basis using the commercial fishery length composition of western Georges Bank landings with the addition of all US length samples from eastern Georges Bank (Table B2). Canadian commercial fishery age-length keys from eastern Georges Bank were used for quarters 2, 3, and 4, while the Canadian spring survey age-length key was used for quarter 1. Canadian commercial fishery length sampling ($n=67,905$ fish) was over 10-fold greater than US fishery length sampling ($n=5,276$ fish). Canadian commercial fishery age sampling ($n=1,393$ fish) was comparable to US fishery length sampling ($n=1,985$ fish). The US fishery catch-at-age data was combined with the Canadian fishery catch-at-age data to compute total catch at age (Table B3).

2.2 Survey Indices

US spring survey indices were computed for 2001-2002 (Table B4) and US autumn survey indices were computed for 2001 (Table B5) using standardized data. Canadian survey indices for 2001-2002 (Table B6) were provided by DFO, Canada (Stratis Gavaris, personal

communication). Canadian survey indices in 2001-2002 were lower than the record high 2000 index which included unusually large catches in stratum 5Z8. Survey maturity-at-age analyses from the 2001 assessment were used for computing spawning biomass.

3.0 Assessment Results

3.1 VPA Results

An updated VPA analysis for Georges Bank haddock was conducted. The VPA formulation was identical to that used for the 2001 assessment, with the exception that the US spring survey was used for tuning in the terminal year. The updated VPA had a total of 30 new survey index values for calibration. VPA diagnostics indicated a good fit to the survey data with maximal coefficients of variation of catchability ranging from 0.14 to 0.34 across surveys.

VPA results indicate that total stock size increased (Table B7) from 80.5 million fish in 2000 to 111.4 million fish in 2002 (+38%). Spawning biomass increased (Table B8, Figure B3) from 59,000 mt in 2000 to 74,400 mt in 2001 (+26%). Fishing mortality (average ages 4-7, unweighted) increased from 0.19 in 2000 to 0.22 in 2001 (+16%; Table B9, Figure B4). Results indicate that the 1998 (39.5 million) and 2000 (75.1) year classes are the strongest since 1978. Preliminary indications are that the 2001 year class may be well below average. Retrospective analysis suggests a random pattern of retrospective estimation errors (Figure B5). Bootstrap analysis indicates that estimates of spawning biomass and F in 2001 are relatively precise with coefficients of variation of 9-10%.

3.2 Sensitivity Analyses

3.2.1 Potential Survey Trawl Warp Inconsistencies during 2000-2002

Measurements of NEFSC survey trawl warps in autumn 2002 suggested that right and left warps may have been offset by up to several feet during winter 2000 through spring 2002 surveys. To evaluate the sensitivity of VPA results to potential undercapture of fish, NEFSC spring and autumn survey indices were arbitrarily adjusted upwards by 10%, 25%, and 100% for spring 2000 through spring 2002 (Figure B6). Results are summarized in Section 5.2 (Summary of Assessment Advice).

3.2.2 Influence of Survey Index Time Series Selection

VPA analysis for Georges Bank haddock includes three survey index time series (US spring, US fall, and Canadian spring). To evaluate sensitivity of baseline results to selection of survey index time series, VPA analyses were conducted using only one index for calibration. Results indicate that the baseline results are closely matched by one-index results for US spring and US fall indices while one-index results for the Canadian spring index produce higher spawning biomass and lower F estimates than the baseline.

4.0 Sources of Uncertainty

- US catch-at-age data for eastern Georges Bank haddock landings are less certain than for western Georges Bank haddock. Improved sampling of US landings from eastern Georges Bank haddock would improve precision of US catch-at-age data.
- Proration of landings are based on preliminary logbook data and are subject to change.

5.0 Summary Stock Status

5.1 Biological Reference Points

For Georges Bank haddock, spawning biomass (B_{MSY}) and the proxy fishing mortality (F_{MSY}) to produce MSY are $B_{MSY} = 250,300$ mt and $F_{MSY} = 0.263$ (NEFSC 2002). The overfished threshold ($B_{THRESHOLD}$) for Georges Bank haddock is $B_{THRESHOLD} = \frac{1}{2} B_{MSY} = 125,200$ mt. The overfishing threshold ($F_{THRESHOLD}$) for Georges Bank haddock is $F_{THRESHOLD} = F_{MSY} = 0.26$.

5.2 Stock Status in 2001

In 2001, spawning biomass was 74,400 mt (59% of $B_{THRESHOLD}$ and 30% of B_{MSY}). Therefore, the Georges Bank haddock stock was overfished in 2001. In 2001, the fishing mortality was 0.22 (85% of $F_{THRESHOLD}$). Therefore, overfishing was not occurring on the Georges Bank haddock stock in 2001.

5.3 Projections

Age-structured projections were conducted to compute $F_{REBUILD}$ for 2003-2009. A two-stage resampling model using the cumulative distribution function of observed recruitment with a cutoff spawning biomass value of 75,000 mt was updated using recruitment results from the baseline VPA and updated mean weights at age and selectivities based on 1999-2001 averages. The assumed value of fishing mortality in 2002 was $F_{2002} = 0.85 * F_{2001} = 0.19$. The assumed 15% reduction in F from 2001 to 2002 is based on environmental impact analyses of the probable impacts of implementing the Settlement Agreement for the Amendment 9 groundfish lawsuit during fishing year 2002.

Projection results indicate that $F_{REBUILD} = 0.197$ (Table B10, Figure B7). Median projected spawning biomass and landings in 2009 under $F_{REBUILD}$ are 250,300 mt and 38,300 mt. Median projected landings in 2002, 2003, and 2004 are 12,500 , 17,800 , and 19,400 mt, respectively. Average projected landings for fishing years 2002-2003 and 2003-2004 are 15,000 and 18,600 mt.

6.0 References

Brown, R. W., and N. J. Munroe. 2000. Stock assessment of Georges Bank haddock, 1931-1999. Northeast Fisheries Science Center Ref. Doc. 00-12, NEFSC, Woods Hole, MA 02543.

Northeast Fisheries Science Center [NEFSC]. 2002. Final Report of the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish. NEFSC Reference Document 02-04, Woods Hole, MA, 02543.

Table B1. Commercial landings (mt) of haddock from Georges Bank and south (NAFO Division 5Z and Subarea 6), 1960-2001.¹

Year	U.S.	Canada	USSR	Spain	Other	Total
1960	40800	77	0	0	0	40877
1961	46384	266	0	0	0	46650
1962	49409	3461	1134	0	0	54004
1963	44150	8379	2317	0	0	54846
1964	46512	11625	5483	2	464	64086
1965	52823	14889	81882	10	758	150362
1966	52918	18292	48409	1111	544	121274
1967	34728	13040	2316	1355	30	51469
1968	25469	9323	1397	3014	1720	40923
1969	16456	3990	65	1201	540	22252
1970	8415	1978	103	782	22	11300
1971	7306	1630	374	1310	242	10862
1972	3869	609	137	1098	20	5733
1973	2777	1563	602	386	3	5331
1974	2396	462	109	764	559	4290
1975	3989	1358	8	61	4	5420
1976	2904	1361	4	46	9	4324
1977	7934	2909	0	0	0	10843
1978	12160	10179	0	0	0	22339
1979	14279	5182	0	0	0	19461
1980	17470	10017	0	0	0	27487
1981	19176	5658	0	0	0	24834
1982	12625	4872	0	0	0	17497
1983	8682	3208	0	0	0	11890
1984	8807	1463	0	0	0	10270
1985	4273	3484	0	0	0	7757
1986	3339	3415	0	0	0	6754
1987	2156	4703	0	0	0	6859
1988	2492	4046 ²	0	0	0	6538
1989	1430	3059	0	0	0	4489
1990	2001	3340	0	0	0	5341
1991	1395	5446	0	0	0	6841
1992	2005	4061	0	0	0	6066
1993	687	3727	0	0	0	4414
1994	218 ³	2411	0	0	0	2629
1995	218 ³	2064	0	0	0	2282
1996	313 ³	3643	0	0	0	3956
1997	888 ³	2622	0	0	0	3510
1998	1841 ³	3371	0	0	0	5212
1999	2775 ³	3680	0	0	0	6455
2000	3366 ³	5402	0	0	0	8768
2001	4637 ³	6712	0	0	0	11349

¹All landings 1960-1979 are from Clark et al. (1982); U.S. landings 1980-1981 are from Overholtz et al. (1983); U.S. landings 1982-1993 are from NMFS, NEFSC Detailed Weighout Files and Canvas data; Canadian landings 1980-1998 from Gavaris and Van Eeckhaute (1999); Canadian landings in 1999-2001 from S. Gavaris (Personal Communication).

²1895 tons were excluded because of suspected misreporting (Gavaris and Van Eeckhaute 1995).

³U.S. landings from 1994-1999 are prorated using Vessel Trip Report data and are considered provisional.

Table B2. U.S. sampling of commercial haddock landings for length and age composition from Georges Bank and south (NAFO Division 5Z and Subarea 6), 1982-2001. Eastern Georges (statistical areas 561, 562, 523 and 524), Western Georges (521, 522, 525, 526, 537, 538, 539 and Subarea 6). Q1, Q2, Q3, Q4, denote quarters 1, 2, 3, and 4, respectively.

Number of Samples				Number of Samples by Market Category, Area, and Quarter																	Annual Sampling Intensity						
				<u>Scrod</u>								<u>Large</u>									No. of Tons Landed/Sample						
				<u>Eastern Georges</u>				<u>Western Georges</u>				<u>Eastern Georges</u>				<u>Western Georges</u>					<u>East</u>	<u>West</u>	<u>East</u>	<u>West</u>			
Year	No.	# Fish Meas.	# Fish Aged	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	<u>Scrod</u>		<u>Large</u>	
1982	89	7851	1788	6	7	6	3	22	1	4	15	4	24	3	9	8	4	24	1	4	7	7	19	96	54	172	264
1983	104	8955	2000	3	9	4	4	20	2	5	8	2	17	7	9	6	5	27	2	12	17	5	38	54	35	139	95
1984	57	4762	1142	11	4	2	1	18	0	1	2	3	6	9	7	1	5	22	3	3	2	3	11	56	65	122	299
1985	32	2528	627	7	4	2	0	13	0	1	2	1	4	7	1	1	0	9	1	0	4	1	6	18	136	161	338
1986	30	2276	571	2	3	1	0	6	0	1	2	1	4	4	2	3	2	11	1	2	3	3	9	186	77	98	92
1987	36	2573	837	2	7	0	1	10	0	0	3	1	4	3	4	1	3	11	2	1	6	2	11	51	41	168	52
1988	34	2542	1096	2	4	2	4	12	1	2	2	0	5	5	4	1	4	14	1	1	1	0	3	61	47	69	186
1989	23	1548	856	4	1	1	1	7	0	1	7	1	9	2	2	0	1	5	1	1	0	0	2	50	29	87	189
1990	27	2001	945	5	5	1	2	13	1	1	1	1	4	1	5	0	1	7	2	0	1	0	3	46	77	84	167
1991	32	1065	439	3	3	0	3	9	0	0	7	0	7	0	9	0	3	12	4	0	0	0	4	56	48	35	31
1992	54	2456	922	7	10	5	0	22	3	4	0	0	7	3	8	2	0	11	3	4	5	0	12	46	38	56	9
1993	31	1140	533	3	3	0	0	6	2	3	3	2	10	0	11	0	0	11	0	0	2	2	4	30	27	13	20
1994	8	546	212	0	0	1	0	1	0	1	0	1	2	0	0	1	0	1	2	1	0	1	4	11	46	22	23
1995	3	198	58	0	0	0	0	0	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0	∞	25	∞	∞
1996	6	524	191	0	0	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	1	3	4	6	30	∞	50
1997	34	3203	848	0	0	0	0	0	0	1	7	3	10	0	1	0	0	1	1	1	7	13	22	∞	22	33	10
1998	24	1692	686	0	0	0	0	0	7	2	1	2	12	1	0	0	0	1	3	3	3	2	11	∞	26	271	111
1999	28	2268	595	0	0	0	0	0	1	0	5	6	12	0	1	1	0	2	4	4	1	5	14	∞	60	131	122
2000	51	3699	1256	1	3	1	4	9	5	2	6	8	21	0	0	1	0	1	7	5	2	6	20	6	37	54	114
2001	72	5276	1985	1	1	1	0	3	6	4	9	6	25	2	3	0	0	5	7	10	13	9	39	99	56	62	67

Table B3. Total catch at age (000's) and mean weight (kg) at age of commercial landings and discards of haddock from Georges Bank and south (NAFO Division 5Z and Statistical Area 6), 1982-2001.

Year	1	2	3	4	5	6	7	8	9+	TOTAL
<u>Total Commercial Catch in Numbers (000's) at Age</u>										
1963	2910	4047	7418	11152	8198	2205	1405	721	1096	39152
1964	10101	15935	4554	4776	8722	5794	2082	1028	1332	54324
1965	9601	125818	44496	5356	4391	6690	3772	1094	1366	202584
1966	114	6843	100810	19167	2768	2591	2332	1268	867	136760
1967	1150	168	2891	20667	10338	1209	993	917	698	39031
1968	8	2994	709	1921	14519	3499	667	453	842	25612
1969	2	11	1698	448	654	5954	1574	225	570	11136
1970	46	158	16	570	186	214	2308	746	464	4708
1971	1	1375	223	40	289	246	285	1469	928	4856
1972	156	2	450	81	32	120	78	66	1236	2221
1973	2560	2075	3	386	53	30	77	15	447	5646
1974 ²	46	4320 ²	657	2	70	2	2	53	249	5401
1975	192	1034	1864	375	4	42	4	4	88	3607
1976	144	473	550	880	216	0	23	4	112	2402
1977 ³	1	19585 ³	187	680	515	357	4	39	111	21479
1978 ⁴	1	761	14395 ⁴	305	567	517	139	14	67	16766
1979	1	26	1726	7169	525	410	315	96	46	10314
1980 ⁵	8	31000 ⁵	347	975	6054	594	546	153	81	39758
1981	1	1743	10998	831	937	2572	331	158	94	17665
1982	1	1165	1633	3733	391	569	1119	106	110	8827
1983	0	214	813	690	2239	272	186	800	76	5290
1984	0	93	297	727	397	1482	234	267	543	4041
1985	0	2406	550	194	461	228	526	78	152	4596
1986	6	54	2810	223	146	173	150	266	60	3888
1987	0	1995	129	1613	122	73	89	106	135	4262
1988	4	52	2384	134	931	149	55	64	106	3879
1989	0	1263	86	877	143	358	46	28	45	2846
1990	2	11	1445	172	868	98	177	46	44	2863
1991	6	448	91	2149	102	410	73	154	72	3505
1992	7	247	320	132	1527	111	323	27	94	2788
1993	7	290	350	299	104	659	38	159	76	1980
1994 ⁶	1.2	268.9	810.4	170.3	65.6	69.3	150.8	43.4	42.7	1623
1995 ⁶	9.2	89.4	596.5	457.2	59.9	31.5	8.2	56.6	18.0	1327
1996 ⁶	5.1	53.6	569.6	946.0	463.6	68.2	21.9	5.4	7.9	2141
1997 ⁶	29.6	174.7	285.3	755.0	547.0	212.1	18.8	15.8	39.6	2078
1998 ⁶	1.0	198.9	414.6	501.1	691.6	526.0	148.5	21.1	41.0	2544
1999	0.9	39.7	1062.2	582.3	497.8	509.9	335.2	142.8	40.9	3211
2000	0.1	390.3	618.3	1578.2	555.9	494.9	361.1	245.6	85.3	4249
2001	2.1	193.8	2684.2	1128.5	1632.7	883.2	580.2	436.6	345.9	7887

Table B3. Continued.

Total Commercial Landings Mean Weight¹(kg) at Age

Year	1	2	3	4	5	6	7	8	9+
1963	0.57	0.87	1.18	1.47	1.68	2.15	2.35	3.04	3.10
1964	0.50	0.83	1.12	1.43	1.64	2.01	2.40	2.64	2.97
1965	0.58	0.69	1.03	1.35	1.67	1.99	2.26	2.66	3.11
1966	0.58	0.73	0.89	1.26	1.70	2.07	2.28	2.87	3.18
1967	0.66	0.70	0.95	1.18	1.42	2.05	2.31	2.66	3.10
1968	0.59	0.81	1.05	1.32	1.57	2.10	2.32	2.62	2.86
1969	0.52	0.78	1.10	1.69	1.75	1.99	2.52	2.99	3.63
1970	0.71	1.27	1.22	1.93	2.19	2.39	2.58	3.23	3.75
1971	(0.67)	1.03	1.31	1.74	2.39	2.81	2.92	3.10	3.72
1972	0.62	1.03	1.74	2.04	2.42	2.92	3.06	3.44	3.66
1973	0.60	1.03	1.58	2.13	2.41	3.29	3.42	3.86	3.94
1974	0.72	1.06	1.82	2.32	2.83	3.76	4.05	3.92	4.26
1975	0.62	0.98	1.63	2.21	2.20	2.94	4.00	4.05	4.33
1976	0.50	0.99	1.39	1.99	2.66	(3.08)	3.69	4.67	4.94
1977	(0.53)	1.07	1.44	2.17	2.73	3.21	4.15	4.00	4.99
1978	(0.53)	0.94	1.50	2.04	2.79	3.19	3.37	3.61	5.11
1979	(0.53)	1.00	1.28	2.02	2.51	3.14	3.78	3.79	4.87
1980	0.55	0.94	1.21	1.73	2.17	2.82	3.60	3.56	3.87
1981	0.39	0.87	1.24	1.83	2.30	2.72	3.71	4.04	4.44
1982	0.22	0.97	1.45	1.88	2.37	2.76	3.24	3.96	4.09
1983	(0.33)	1.02	1.37	1.83	2.21	2.65	3.25	3.36	4.27
1984	(0.33)	0.92	1.32	1.83	2.20	2.67	2.96	3.41	3.72
1985	(0.33)	0.99	1.39	1.98	2.46	2.72	3.06	3.72	3.80
1986	0.45	0.94	1.36	1.83	2.56	2.83	2.96	3.46	3.78
1987	(0.43)	0.83	1.43	2.00	2.25	2.63	3.02	3.77	4.29
1988	0.42	0.98	1.34	1.68	2.06	2.45	2.97	3.49	3.96
1989	(0.53)	0.89	1.48	1.79	2.21	2.57	3.24	3.56	3.82
1990	0.64	0.97	1.48	1.78	2.12	2.55	2.81	2.99	4.16
1991	0.581	1.201	1.311	1.817	2.183	2.645	2.852	3.048	4.337
1992	0.538	1.175	1.639	1.768	2.186	2.519	2.967	3.365	4.267
1993	0.659	1.169	1.728	2.171	2.119	2.628	2.649	3.123	4.014
1994	0.447	1.093	1.643	2.209	2.628	2.728	2.902	3.783	4.546
1995	0.429	0.967	1.489	2.025	2.542	2.815	3.275	3.091	3.981
1996	0.456	1.098	1.497	1.838	2.325	2.543	3.423	3.516	3.712
1997	0.416	0.998	1.690	1.891	2.213	2.547	3.1.4	3.380	3.655
1998	0.511	0.968	1.485	1.917	2.333	2.688	3.027	3.038	4.070
1999	0.678	1.101	1.527	1.830	2.111	2.339	2.697	2.973	3.682
2000	0.664	1.133	1.464	1.893	2.252	2.372	2.732	2.991	3.298
2001	0.394	1.228	1.465	1.761	2.159	2.527	2.622	2.736	3.395

¹Data 1963-1979 from Clark et al. (1982); Data 1980-1981 from Overholtz et al. (1983); Data 1982-1990 from Hayes and Buxton (1992); data from 1991-1994 from O'Brien and Brown (1996); data from 1995-2001 from current assessment, Gavaris and Van Eekhaute (1999), and S. Gavaris (personal communication).

²Of this total, approximately 1.0 million fish were added to the catch at age to account for high discards in 1974.

³Of this total, approximately 12.8 million fish were added to the catch at age to account for high discards in 1977.

⁴Of this total, approximately 5.0 million fish were added to the catch at age to account for high discards in 1978.

⁵Of this total, approximately 20.0 million fish were added to the catch at age to account for high discards in 1980.

⁶Total includes discards resulting from trip limit regulations for most year classes.

Table B4. Stratified mean catch per tow (numbers) for haddock in NEFSC offshore spring research vessel bottom trawl surveys on Georges Bank (Strata 01130-01250, 01290-01300), 1968-2002. Indices have been corrected to account for changes in catchability due to changes in research vessels and doors.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total
1968	0.40	2.83	0.46	0.70	6.72	1.68	0.25	0.45	0.34	13.83
1969	0.00	0.07	0.58	0.25	0.42	4.23	1.03	0.28	0.46	7.32
1970	0.67	0.25	0.00	0.33	0.46	0.46	2.00	0.98	0.85	6.00
1971	0.00	1.16	0.25	0.00	0.12	0.12	0.09	0.82	0.22	2.78
1972	4.02	0.09	0.61	0.12	0.03	0.04	0.13	0.03	1.30	6.37
1973	30.68	4.84	0.00	0.54	0.09	0.00	0.18	0.01	1.28	37.62
1974	2.13	13.29	2.86	0.00	0.24	0.00	0.01	0.10	0.37	19.00
1975	0.94	0.97	3.32	0.63	0.00	0.13	0.09	0.01	0.15	6.24
1976	80.79	0.30	0.60	0.92	0.43	0.00	0.04	0.00	0.10	83.18
1977	0.61	33.41	0.42	1.22	0.60	0.45	0.00	0.04	0.12	36.87
1978	0.07	0.97	15.93	0.36	0.94	0.82	0.16	0.06	0.10	19.41
1979	36.12	1.58	1.13	5.71	0.33	0.16	0.37	0.06	0.04	45.50
1980	5.20	46.70	0.51	1.04	4.87	0.67	0.37	0.46	0.24	60.06
1981	3.30	3.29	19.49	2.19	0.76	1.78	0.24	0.11	0.05	31.21
1982	0.76	1.53	0.94	4.07	0.42	0.28	0.61	0.00	0.00	8.61
1983	0.43	0.55	0.58	0.22	2.41	0.01	0.04	1.16	0.18	5.58
1984	2.09	1.18	0.64	0.63	0.58	0.72	0.07	0.04	0.30	6.25
1985	0.00	4.96	0.76	0.40	0.87	0.34	1.17	0.10	0.25	8.85
1986	2.49	0.18	2.06	0.24	0.11	0.21	0.12	0.33	0.11	5.85
1987	0.00	3.62	0.06	0.81	0.08	0.10	0.05	0.22	0.01	4.95
1988	1.55	0.04	0.99	0.13	0.32	0.12	0.11	0.12	0.00	3.38
1989	0.02	3.49	0.45	0.71	0.14	0.41	0.06	0.05	0.01	5.34
1990	0.86	0.00	5.72	0.33	0.58	0.06	0.13	0.00	0.01	7.69
1991	0.54	1.07	0.24	1.85	0.09	0.10	0.02	0.04	0.02	3.97
1992	0.40	0.18	0.11	0.07	0.33	0.03	0.03	0.03	0.00	1.18
1993	1.17	0.65	0.18	0.14	0.12	0.37	0.06	0.02	0.02	2.73
1994	0.70	2.68	1.00	0.15	0.10	0.07	0.16	0.02	0.05	4.92
1995	0.50	1.29	2.32	0.91	0.17	0.11	0.03	0.18	0.11	5.61
1996	1.09	4.59	8.86	5.21	2.62	0.35	0.07	0.08	0.00	22.86
1997	1.79	1.02	3.35	3.66	2.01	0.89	0.13	0.07	0.00	12.92
1998	0.82	2.95	1.25	1.06	0.85	0.21	0.06	0.01	0.06	7.28
1999	10.21	2.03	2.14	0.72	0.64	0.51	0.20	0.20	0.02	16.67
2000	1.83	2.37	4.10	2.01	1.11	1.11	1.01	0.48	0.27	14.29
2001	10.01	0.86	2.44	0.83	0.30	0.21	0.12	0.08	0.07	14.92
2002	0.18	19.25	6.72	3.22	1.09	0.48	0.61	0.17	0.53	32.25

Table B5. Stratified mean catch per tow (numbers) for haddock in NEFSC offshore autumn research vessel bottom trawl surveys on Georges Bank (Strata 01130-01250, 01290-01300), 1963-2001. Indices have been corrected to account for changes in catchability due to changes in research vessels and doors.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+	Total
1963	83.93	25.39	9.22	6.81	8.34	5.95	2.04	1.68	1.18	0.46	145.01
1964	2.37	112.87	63.74	5.83	1.79	3.81	1.56	0.69	0.25	0.33	193.24
1965	0.33	10.16	77.39	9.70	1.07	0.80	0.91	0.80	0.25	0.27	101.69
1966	6.14	0.95	2.89	18.39	3.35	0.52	0.49	0.33	0.12	0.07	33.26
1967	0.03	6.72	0.36	1.00	6.76	1.62	0.49	0.21	0.33	0.18	17.70
1968	0.09	0.06	0.95	0.13	0.33	3.86	1.27	0.27	0.16	0.39	7.51
1969	0.39	0.03	0.00	0.28	0.13	0.16	1.52	0.51	0.09	0.27	3.38
1970	0.04	4.13	0.21	0.01	0.28	0.27	0.51	1.37	0.48	0.40	7.70
1971	2.43	0.00	0.31	0.07	0.01	0.22	0.03	0.09	0.75	0.28	4.20
1972	6.75	2.52	0.00	0.52	0.09	0.00	0.09	0.06	0.03	1.30	11.35
1973	3.23	9.00	1.61	0.00	0.19	0.04	0.00	0.07	0.01	0.72	14.89
1974	0.75	1.77	0.98	0.31	0.00	0.01	0.00	0.00	0.00	0.22	4.05
1975	23.48	0.63	0.72	4.86	0.92	0.00	0.03	0.00	0.01	0.30	30.95
1976	4.32	64.17	0.52	0.54	0.82	0.30	0.00	0.04	0.10	0.25	71.07
1977	0.13	2.14	18.73	0.56	0.57	0.64	0.34	0.04	0.01	0.09	23.25
1978	13.22	0.84	1.04	9.27	0.18	0.26	0.45	0.01	0.00	0.01	25.30
1979	1.32	45.57	0.04	0.90	3.81	0.26	0.28	0.05	0.01	0.00	52.24
1980	11.68	2.71	12.72	0.45	0.18	1.70	0.48	0.46	0.09	0.06	30.54
1981	0.38	6.13	2.08	3.70	0.21	0.42	0.53	0.00	0.00	0.01	13.45
1982	1.36	0.00	1.33	0.34	1.40	0.13	0.07	0.21	0.01	0.10	4.96
1983	5.80	0.24	0.21	0.27	0.30	0.94	0.12	0.00	0.10	0.01	7.99
1984	0.03	3.32	0.88	0.24	0.28	0.06	0.45	0.00	0.00	0.12	5.38
1985	11.35	0.65	1.53	0.22	0.05	0.10	0.07	0.17	0.00	0.05	14.19
1986	0.00	5.11	0.09	1.21	0.06	0.13	0.13	0.02	0.03	0.03	6.81
1987	1.80	0.00	0.79	0.10	0.77	0.06	0.06	0.02	0.02	0.00	3.62
1988	0.07	3.02	0.18	1.30	0.12	0.40	0.12	0.11	0.00	0.03	5.35
1989	0.47	0.05	2.71	0.20	0.66	0.09	0.13	0.02	0.02	0.00	4.34
1990	0.77	0.67	0.02	1.19	0.05	0.17	0.04	0.00	0.00	0.00	2.92
1991	2.16	0.21	0.24	0.05	0.22	0.02	0.02	0.00	0.00	0.02	2.92
1992	2.85	2.08	0.23	0.24	0.00	0.47	0.02	0.08	0.03	0.06	6.06
1993	1.52	4.04	2.01	0.30	0.00	0.06	0.15	0.02	0.00	0.00	8.09
1994	0.91	0.77	0.81	0.67	0.12	0.05	0.02	0.17	0.06	0.00	3.58
1995	2.27	7.14	4.90	2.32	0.38	0.01	0.00	0.07	0.02	0.00	17.11
1996	1.31	0.54	0.93	1.04	0.49	0.14	0.01	0.01	0.00	0.01	4.47
1997	0.32	2.47	1.47	0.75	0.55	0.33	0.13	0.00	0.07	0.08	6.16
1998	4.32	2.79	2.47	0.72	0.41	0.18	0.16	0.02	0.00	0.01	11.07
1999	1.82	0.84	3.37	8.05	3.52	2.32	0.82	1.32	0.75	0.31	23.13
2000	4.14	2.82	5.48	3.10	1.10	0.66	0.13	0.27	0.09	0.19	17.99
2001	0.85	8.77	1.68	7.44	2.12	1.16	0.36	0.22	0.13	0.01	22.74

Table B6. Stratified mean catch per tow (numbers) for haddock in Canadian offshore research vessel bottom trawl surveys on Georges Bank, 1986-2002.¹ The Georges Bank strata set includes strata 5Z1-5Z8.

Year	Age group										Total
	0	1	2	3	4	5	6	7	8	9+	
1986	0.00	4.06	0.22	6.05	1.07	0.19	0.29	0.34	0.37	0.42	13.01
1987	0.00	0.03	3.04	0.69	2.51	0.67	0.08	0.30	0.10	0.86	8.28
1988	0.00	1.47	0.05	8.53	0.17	2.85	0.18	0.17	0.11	0.50	14.03
1989	0.00	0.03	5.34	0.72	2.12	0.19	0.42	0.03	0.03	0.23	9.11
1990	0.00	0.93	0.11	9.87	0.13	3.36	0.23	1.09	0.13	0.34	16.19
1991	0.00	0.75	1.67	0.14	8.99	0.11	1.60	0.09	0.44	0.21	14.00
1992	0.00	3.30	2.95	1.13	0.17	3.82	0.03	1.06	0.04	0.58	13.08
1993	0.00	3.96	2.16	0.55	0.45	0.04	1.28	0.02	0.32	0.16	8.94
1994	0.00	3.32	11.52	4.08	0.42	0.24	0.02	0.70	0.01	0.27	20.59
1995	0.00	1.94	2.62	4.30	2.22	0.56	0.28	0.00	0.48	0.66	13.06
1996	0.00	5.37	2.54	4.25	4.43	2.57	0.23	0.21	0.03	0.50	20.14
1997	0.00	1.74	1.15	0.81	2.36	2.47	1.77	0.24	0.09	0.59	11.22
1998	0.00	2.41	8.18	3.08	2.57	3.76	3.67	1.98	0.24	0.48	26.37
1999	0.00	19.75	3.41	7.16	2.21	1.40	1.35	1.26	0.33	0.13	37.00
2000	0.00	18.33	68.60	9.32	8.91	2.11	1.55	1.94	1.14	0.59	112.50
2001	0.00	22.28	2.83	10.88	3.09	4.13	1.29	1.15	1.41	1.65	48.71
2002	0.00	1.98	31.70	6.65	15.36	4.32	5.32	1.59	1.32	7.73	75.97

¹ S. Gavaris Personal communication.

Table B7. Beginning year stock size (000s) of Georges Bank haddock estimated from the VPA, 1963 to 2002.

Age	1963	1964	1965	1966	1967	1968	1969
1	192405	486215	32602	4081	13172	420	984
2	32188	154895	388939	18005	3238	9744	336
3	33117	22691	112399	204592	8549	2499	5268
4	46437	20401	14458	51763	76289	4384	1405
5	29224	27929	12382	6991	25037	43760	1851
6	9696	16509	14974	6164	3219	11144	22690
7	6014	5943	8274	6207	2702	1541	5958
8	2799	3652	2982	3361	2971	1314	658
9	4224	4695	3685	2274	2242	2419	1652
1+	356105	742932	590695	303437	137420	77225	40804
	1970	1971	1972	1973	1974	1975	1976
1	4773	473	8507	19485	10792	7623	102890
2	804	3866	387	6824	13636	8794	6067
3	265	515	1921	315	3709	7256	6265
4	2777	203	220	1166	255	2443	4254
5	745	1758	130	107	605	207	1660
6	924	441	1178	77	40	432	166
7	13190	562	139	856	36	31	316
8	3454	8710	203	43	631	28	21
9	2135	5475	3761	1271	2954	610	598
1+	29066	22004	16444	30143	32659	27422	122237
	1977	1978	1979	1980	1981	1982	1983
1	14364	5984	84420	10102	7221	2502	3099
2	84109	11760	4898	69116	8264	5911	2048
3	4540	51141	8939	3987	28537	5189	3786
4	4631	3548	28846	5757	2950	13413	2770
5	2686	3177	2628	17130	3831	1663	7604
6	1164	1733	2088	1677	8547	2289	1008
7	136	630	951	1338	836	4670	1359
8	238	107	390	494	602	385	2811
9	673	512	186	259	355	396	265
1+	112541	78592	133346	109861	61143	36419	24750

Table B7. Continued.

	1984	1985	1986	1987	1988	1989	1990
1	17284	1752	14732	2199	16921	1081	2653
2	2537	14151	1434	12056	1800	13850	885
3	1483	1993	9409	1125	8065	1427	10197
4	2364	945	1134	5161	805	4446	1091
5	1644	1277	598	727	2766	538	2847
6	4200	987	629	358	485	1422	311
7	579	2097	602	358	227	262	840
8	945	263	1241	357	213	136	173
9	1906	507	278	451	349	217	164
1+	32941	23973	30057	22791	31631	23379	19160
	1991	1992	1993	1994	1995	1996	1997
1	2419	9903	13861	14240	9802	10908	19940
2	2171	1975	8102	11342	11658	8017	8926
3	715	1372	1393	6371	9043	9464	6515
4	7041	503	834	824	4483	6864	7233
5	737	3820	292	412	521	3256	4764
6	1545	511	1746	145	278	372	2247
7	166	894	318	833	56	199	243
8	528	70	440	226	546	39	143
9	245	240	208	221	173	56	362
1+	15565	19287	27193	34614	36559	39175	50373
	1998	1999	2000	2001	2002		
1	14198	39479	17692	75115	4453		
2	16299	11623	32322	14485	61497		
3	7147	13164	9480	26110	11745		
4	5074	5476	9817	7202	19432		
5	5218	3700	3957	6609	5169		
6	3387	3647	2579	2737	4334		
7	1640	2297	2524	1664	1741		
8	181	1208	1578	1740	1020		
9	351	345	545	1358	2028		
1+	53495	80941	80495	137020	111419		

Table B8. Spawning stock biomass (mt) of Georges Bank haddock estimated from the VPA, 1963 to 2001.

Age	1963	1964	1965	1966	1967	1968	1969
1	00	00	00	00	00	00	00
2	00	00	00	00	00	1710	60
3	24532	15607	66805	97767	4700	1409	3221
4	56925	23391	14829	49168	68052	3958	1597
5	38916	37115	16069	8724	27362	50539	2364
6	17459	25531	21711	9324	4999	16457	35028
7	11770	11365	14076	10997	4935	2718	11957
8	6545	7884	6294	7116	6272	2727	1465
9	11456	12085	9574	6011	5958	5837	5067
1+	167603	132978	149358	189106	122279	85355	60760
	1970	1971	1972	1973	1974	1975	1976
1	00	00	00	00	00	00	00
2	164	777	85	1592	3156	2307	1502
3	184	409	1725	350	4208	7675	6237
4	3609	264	301	1904	463	4449	6829
5	1257	3416	234	185	1365	442	3684
6	1668	820	2873	181	112	1152	410
7	26943	1151	304	2506	124	109	969
8	8755	22254	546	125	2144	103	83
9	7114	18399	11711	4218	11683	2405	2652
1+	49694	47490	17779	11061	23256	18642	22367
	1977	1978	1979	1980	1981	1982	1983
1	00	00	00	00	00	00	00
2	17917	2558	1118	12908	1680	1073	295
3	4128	45484	7116	3295	20671	4034	3143
4	7321	5641	44086	7738	3804	17772	3961
5	5612	7039	5316	30147	6720	3057	13359
6	2917	4403	5529	3748	17850	5064	2200
7	458	1838	2804	3684	2226	12214	3717
8	826	381	1225	1552	2003	1280	8028
9	3039	2395	794	859	1377	1407	979
1+	42218	69739	67988	63931	56331	45902	35682

Table B8. Continued.

	1984	1985	1986	1987	1988	1989	1990
1	377	78	1113	143	1116	97	118
2	434	4751	489	4330	717	5095	337
3	1445	1782	8547	1091	6672	1462	10030
4	3208	1336	1586	7136	1105	6037	1588
5	2903	2271	1184	1333	4754	903	4757
6	8576	2133	1442	829	976	2869	631
7	1331	5258	1498	919	558	665	2009
8	2724	750	3591	1026	594	394	469
9	6141	1660	935	1665	1190	740	595
1+	27139	20018	20385	18472	17682	18263	20534
	1991	1992	1993	1994	1995	1996	1997
1	94	344	472	288	50	64	98
2	950	837	1815	2730	2472	1775	1938
3	694	1597	1236	5742	10124	10006	7842
4	9811	662	1239	1349	7548	10362	11219
5	1325	6260	475	892	1134	6440	8819
6	3189	1065	3478	275	695	850	5052
7	360	2097	755	2070	153	569	634
8	1332	178	1121	642	1508	119	448
9	916	846	699	901	635	190	1216
1+	18672	13886	11291	14889	24319	30376	37266
	1998	1999	2000	2001			
1	94	394	164	246			
2	3530	2817	9127	4220			
3	7939	14799	10566	29361			
4	8299	8639	15117	10647			
5	9552	6685	7325	12026			
6	7098	7408	5173	5831			
7	4185	5333	5814	3672			
8	569	3302	4065	4279			
9	1253	1166	1632	4146			
1+	42518	50541	58984	74429			

Table B9. Fishing mortality (F) at age and average F (ages 4-7, unweighted) for Georges Bank haddock estimated from VPA, 1963 to 2001.

Age	1963	1964	1965	1966	1967	1968	1969
1	0.02	0.02	0.39	0.03	0.10	0.02	0.00
2	0.15	0.12	0.44	0.54	0.06	0.41	0.04
3	0.28	0.25	0.58	0.79	0.47	0.38	0.44
4	0.31	0.30	0.53	0.53	0.36	0.66	0.43
5	0.37	0.42	0.50	0.58	0.61	0.46	0.50
6	0.29	0.49	0.68	0.62	0.54	0.43	0.34
7	0.30	0.49	0.70	0.54	0.52	0.65	0.35
8	0.34	0.37	0.52	0.54	0.42	0.48	0.47
9	0.34	0.37	0.52	0.54	0.42	0.48	0.47
4-7	0.32	0.43	0.60	0.57	0.51	0.55	0.40
	1970	1971	1972	1973	1974	1975	1976
1	0.01	0.00	0.02	0.16	0.00	0.03	0.00
2	0.24	0.50	0.01	0.41	0.43	0.14	0.09
3	0.07	0.65	0.30	0.01	0.22	0.33	0.10
4	0.26	0.25	0.52	0.46	0.01	0.19	0.26
5	0.32	0.20	0.32	0.79	0.14	0.02	0.16
6	0.30	0.96	0.12	0.56	0.06	0.11	0.00
7	0.21	0.82	0.97	0.10	0.06	0.16	0.08
8	0.27	0.21	0.45	0.49	0.10	0.17	0.23
9	0.27	0.21	0.45	0.49	0.10	0.17	0.23
4-7	0.27	0.56	0.48	0.48	0.07	0.12	0.12
	1977	1978	1979	1980	1981	1982	1983
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.30	0.07	0.01	0.68	0.27	0.25	0.12
3	0.05	0.37	0.24	0.10	0.55	0.43	0.27
4	0.18	0.10	0.32	0.21	0.37	0.37	0.32
5	0.24	0.22	0.25	0.50	0.32	0.30	0.39
6	0.41	0.40	0.24	0.50	0.40	0.32	0.35
7	0.03	0.28	0.46	0.60	0.58	0.31	0.16
8	0.20	0.16	0.32	0.42	0.34	0.36	0.38
9	0.20	0.16	0.32	0.42	0.34	0.36	0.38
4-7	0.22	0.25	0.32	0.45	0.42	0.32	0.31

Table B9. Continued.

	1984	1985	1986	1987	1988	1989	1990
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.04	0.21	0.04	0.20	0.03	0.11	0.01
3	0.25	0.36	0.40	0.14	0.40	0.07	0.17
4	0.42	0.26	0.25	0.42	0.20	0.25	0.19
5	0.31	0.51	0.31	0.21	0.47	0.35	0.41
6	0.49	0.29	0.36	0.26	0.42	0.33	0.43
7	0.59	0.32	0.32	0.32	0.31	0.22	0.26
8	0.37	0.40	0.27	0.40	0.40	0.26	0.35
9	0.37	0.40	0.27	0.40	0.40	0.26	0.35
4-7	0.45	0.35	0.31	0.30	0.35	0.28	0.32
	1991	1992	1993	1994	1995	1996	1997
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.26	0.15	0.04	0.03	0.01	0.01	0.02
3	0.15	0.30	0.33	0.15	0.08	0.07	0.05
4	0.41	0.34	0.50	0.26	0.12	0.17	0.13
5	0.17	0.58	0.50	0.19	0.14	0.17	0.14
6	0.35	0.27	0.54	0.75	0.13	0.23	0.11
7	0.67	0.51	0.14	0.22	0.18	0.13	0.09
8	0.39	0.56	0.51	0.24	0.12	0.17	0.13
9	0.39	0.56	0.51	0.24	0.12	0.17	0.13
4-7	0.40	0.43	0.42	0.36	0.14	0.17	0.12
	1998	1999	2000	2001			
1	0.00	0.00	0.00	0.00			
2	0.01	0.00	0.01	0.01			
3	0.07	0.09	0.07	0.10			
4	0.12	0.13	0.20	0.13			
5	0.16	0.16	0.17	0.22			
6	0.19	0.17	0.24	0.25			
7	0.11	0.18	0.17	0.29			
8	0.14	0.14	0.19	0.22			
9	0.14	0.14	0.19	0.22			
4-7	0.14	0.16	0.19	0.22			

Table B10. Input data and results for short-term (2002-2005) stochastic stock biomass and catch projections for Georges Bank haddock.

Input for Projections:

Number of Years: 3; Initial Year: 2002; Final Year: 2005
 Number of Ages : 9; Age at Recruitment: 1; Last Age: 9
 Natural Mortality is assumed Constant over time at: .200
 Proportion of F before spawning: .25
 Proportion of M before spawning: .25
 Last age is a PLUS group;

Age-specific Input data for Projection # 1

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Catch	weights Stock
1	.0010	1.0000	.0400	0.579	0.395
2	.0460	1.0000	.4900	1.154	0.843
3	.4880	1.0000	.9500	1.485	1.282
4	.8290	1.0000	1.0000	1.828	1.672
5	1.0000	1.0000	1.0000	2.174	2.010
6	1.0000	1.0000	1.0000	2.413	2.284
7	1.0000	1.0000	1.0000	2.684	2.524
8	1.0000	1.0000	1.0000	2.900	2.850
9+	1.0000	1.0000	1.0000	3.458	3.458

Projections for 2002-2005; F(2002)=0.19; Basis: 85% of 2001 point estimate. Recruitment (age 1) 2002-2004 year classes derived from two-stage resampling of 1931-2001 stock-recruitment data excluding the 1963 year class with a 75,000 mt spawning biomass cutoff.

SSB was estimated to be 74,400 mt in 2001.

2002			2003		
F	Catch	SSB	F	Catch	SSB
0.19	12462	99737	$F_{rebuild} = 0.197$	17840	122264
0.19	12462	99737	$F_{sq} = 0.190$	17252	122415
2004			2005		
F	Catch	SSB	F	Catch	SSB
0.197	19432	131712	0.197	22488	158330
0.190	18887	132413	0.190	21929	159533

Figure B1. Total commercial landings (thousand mt) of haddock from Georges Bank and south, 1904-2001.

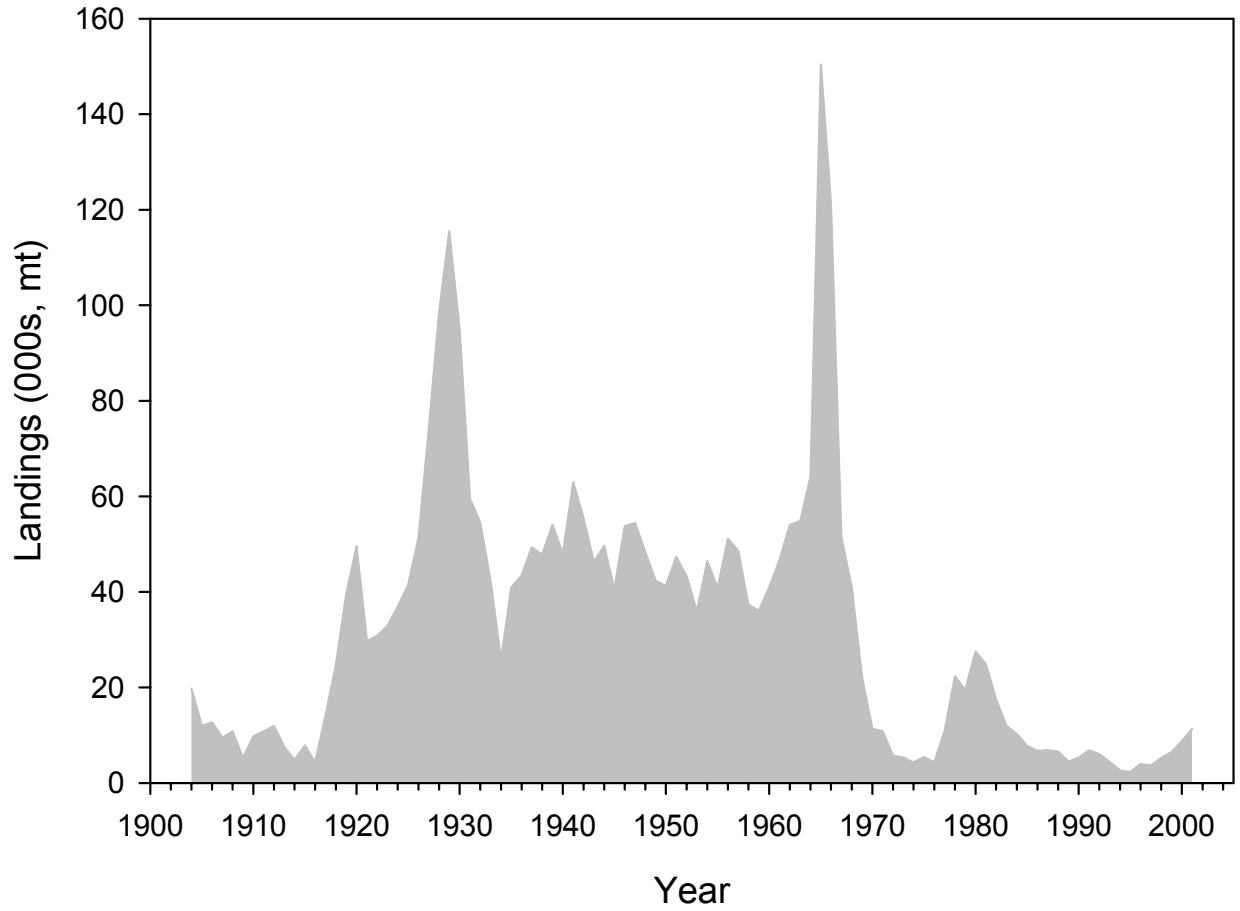


Figure B2. Georges Bank haddock research survey indices, 1963-2002.

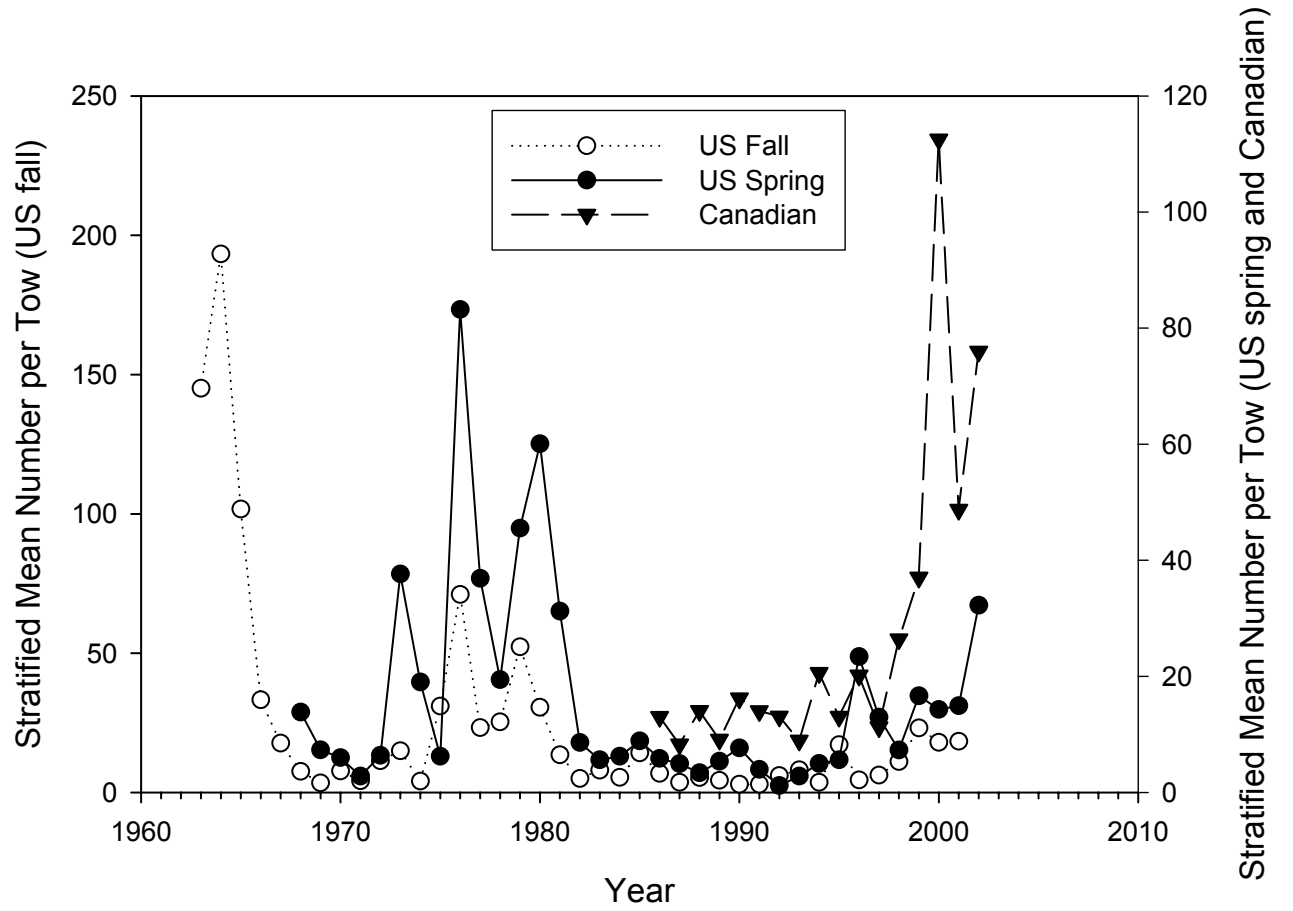


Figure B3. Trends in spawning stock biomass (line) and recruitment (bars) for Georges Bank haddock from 1931-2001.

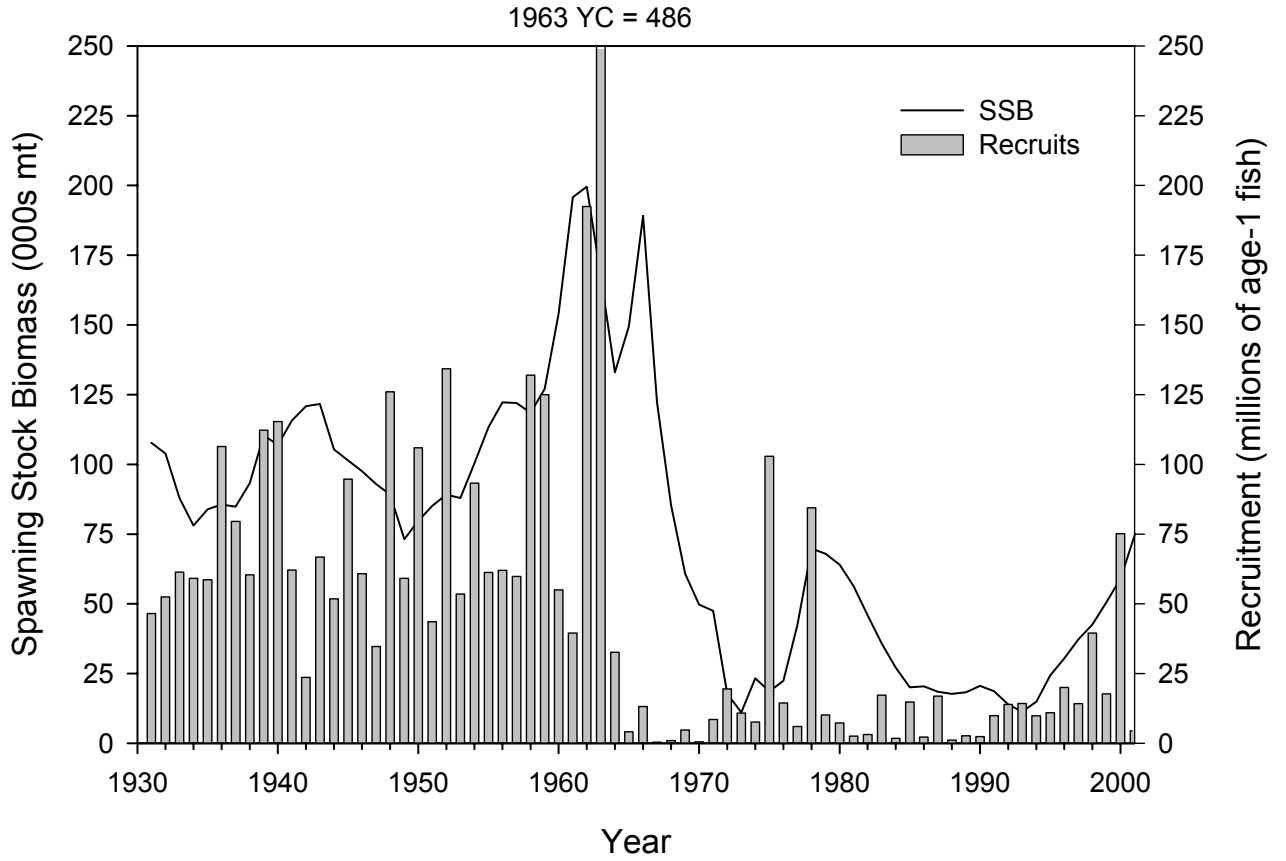
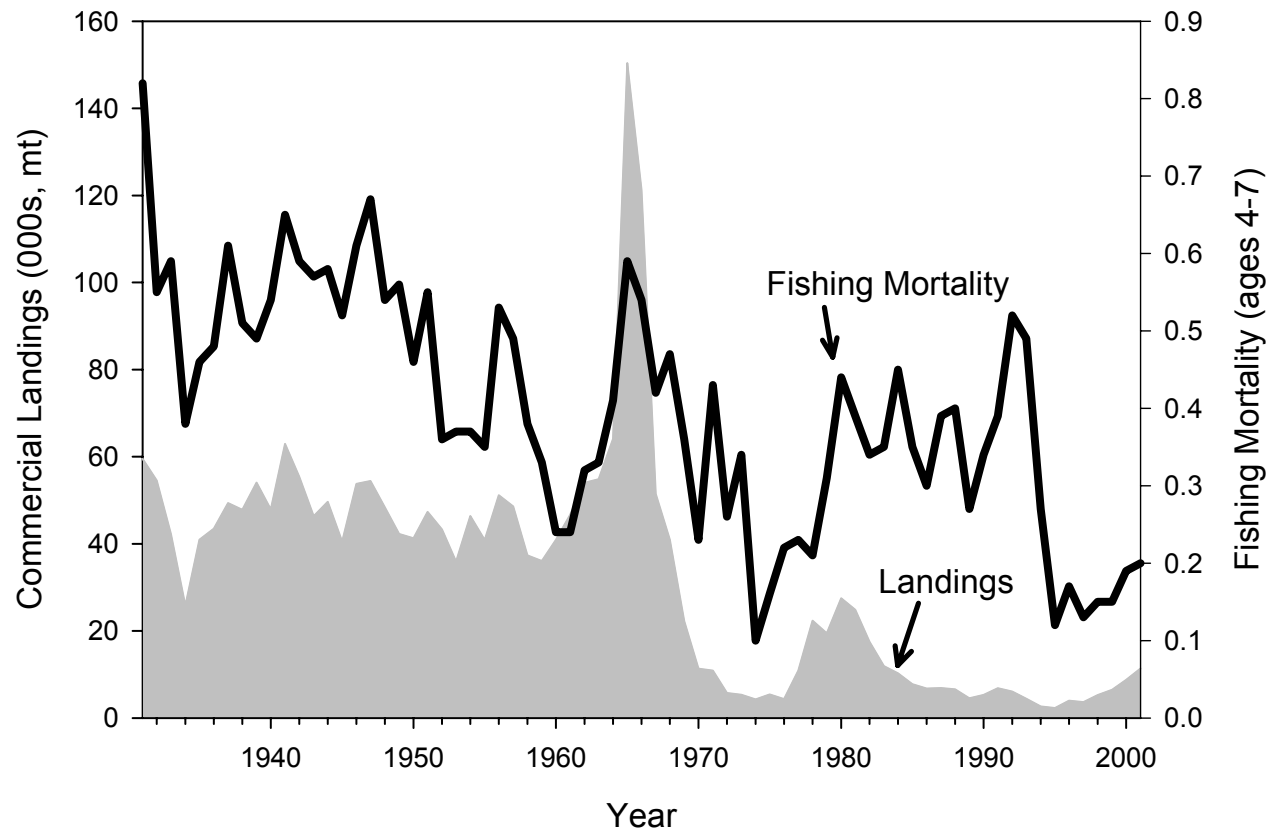


Figure B4. Trends in commercial landings (thousand mt, live weight) and fishing mortality (unweighted mean, ages 4-7) for Georges Bank haddock from 1931-2001.



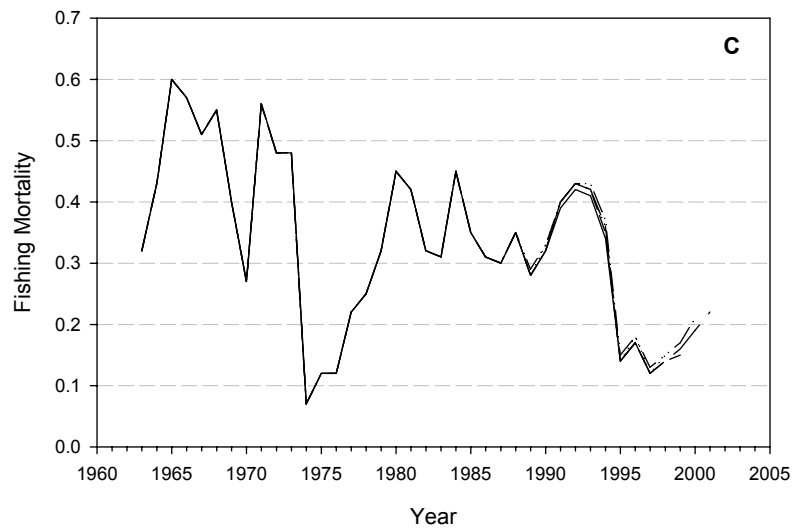
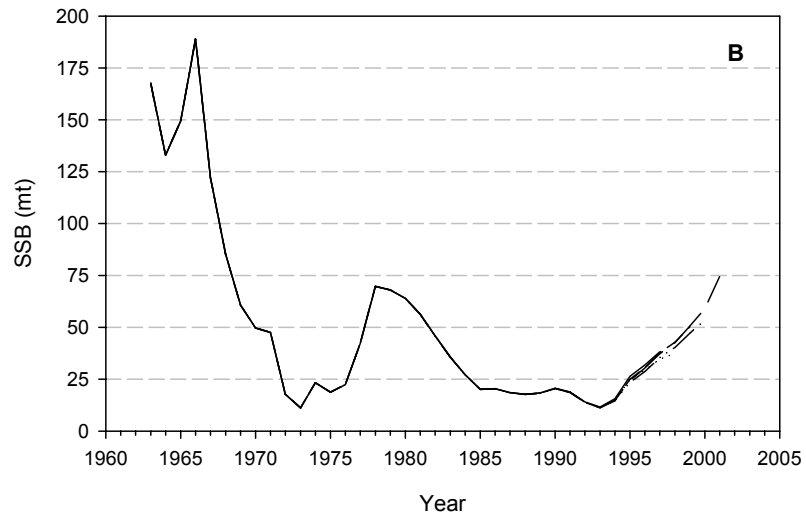
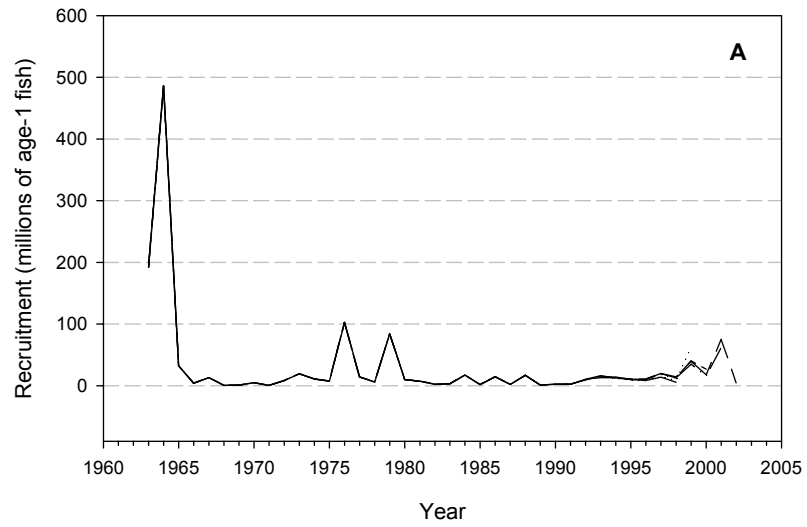


Figure B5. Retrospective analysis of Georges Bank haddock recruitment (A), spawning stock biomass (B) and fishing mortality (C).

Figure B6. Georges Bank haddock sensitivity to hypothetical NEFSC survey index adjustments due to trawl warp offsets during 2000-2002.

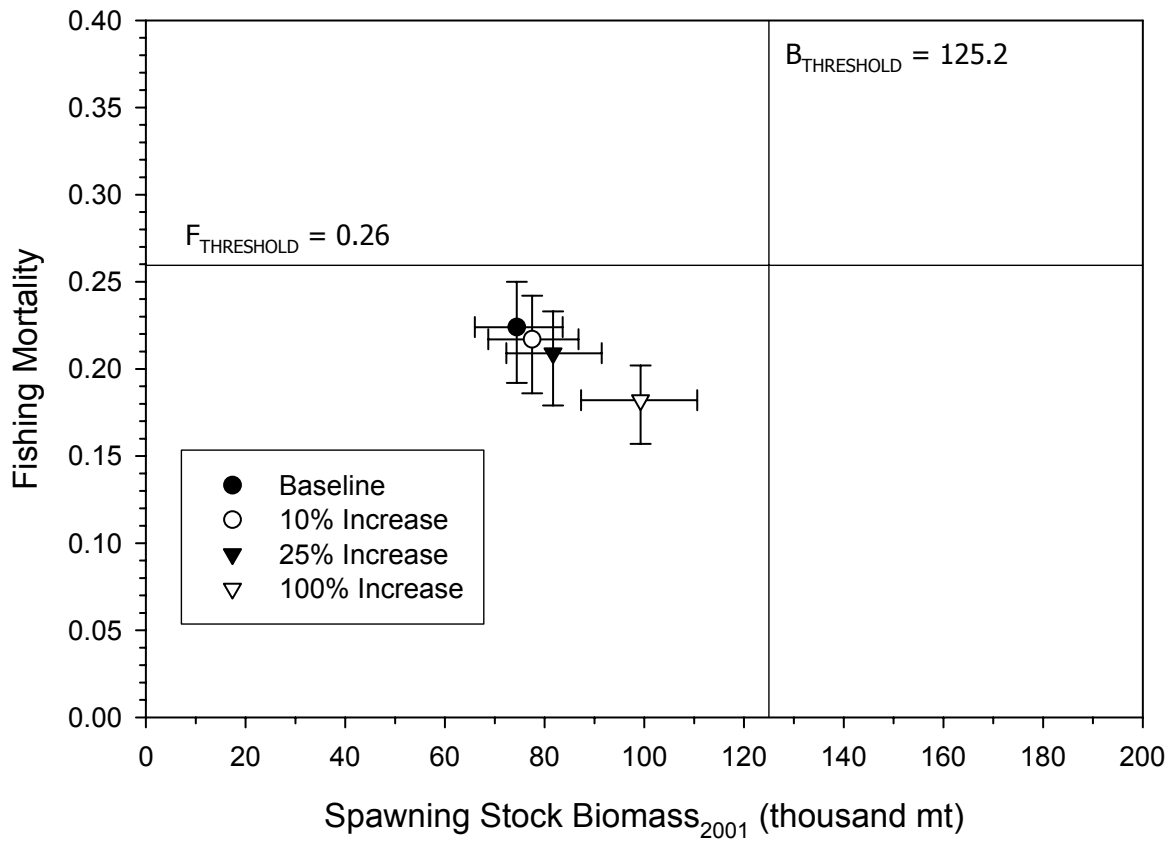


Figure B7. Georges Bank haddock projection results for $F=F_{REBUILD}$.

